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**Amano et al.**

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(54) **PROJECTION-TYPE IMAGE DISPLAY  
DEVICE AND PROJECTION-TYPE IMAGE  
DISPLAY SYSTEM**

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(51) **Int. Cl.**

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**G03B 21/22** (2006.01)  
**G03B 21/14** (2006.01)  
**G02B 5/08** (2006.01)

(57) **ABSTRACT**

A projection-type image display device includes an image  
light generator configured to generate image light, a projec-  
tion optics configured to project the image light onto a screen.  
The projection optics includes a reflection mirror configured  
to reflect the image light toward the screen, the image light  
outputted from the image light generator. A projection-type  
image display device includes a protective cover provided on  
an optical path of the image light reflected by the reflection  
mirror. The protective cover has a transmissive region trans-  
mitting the image light reflected by the reflection mirror.

(52) **U.S. Cl.**

USPC ..... **353/98**; 353/119; 359/838

(58) **Field of Classification Search**

USPC ..... 353/98, 99, 77, 78, 72, 74, 119;  
348/794; 352/242; 359/858, 838, 850  
See application file for complete search history.

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**6 Claims, 12 Drawing Sheets**

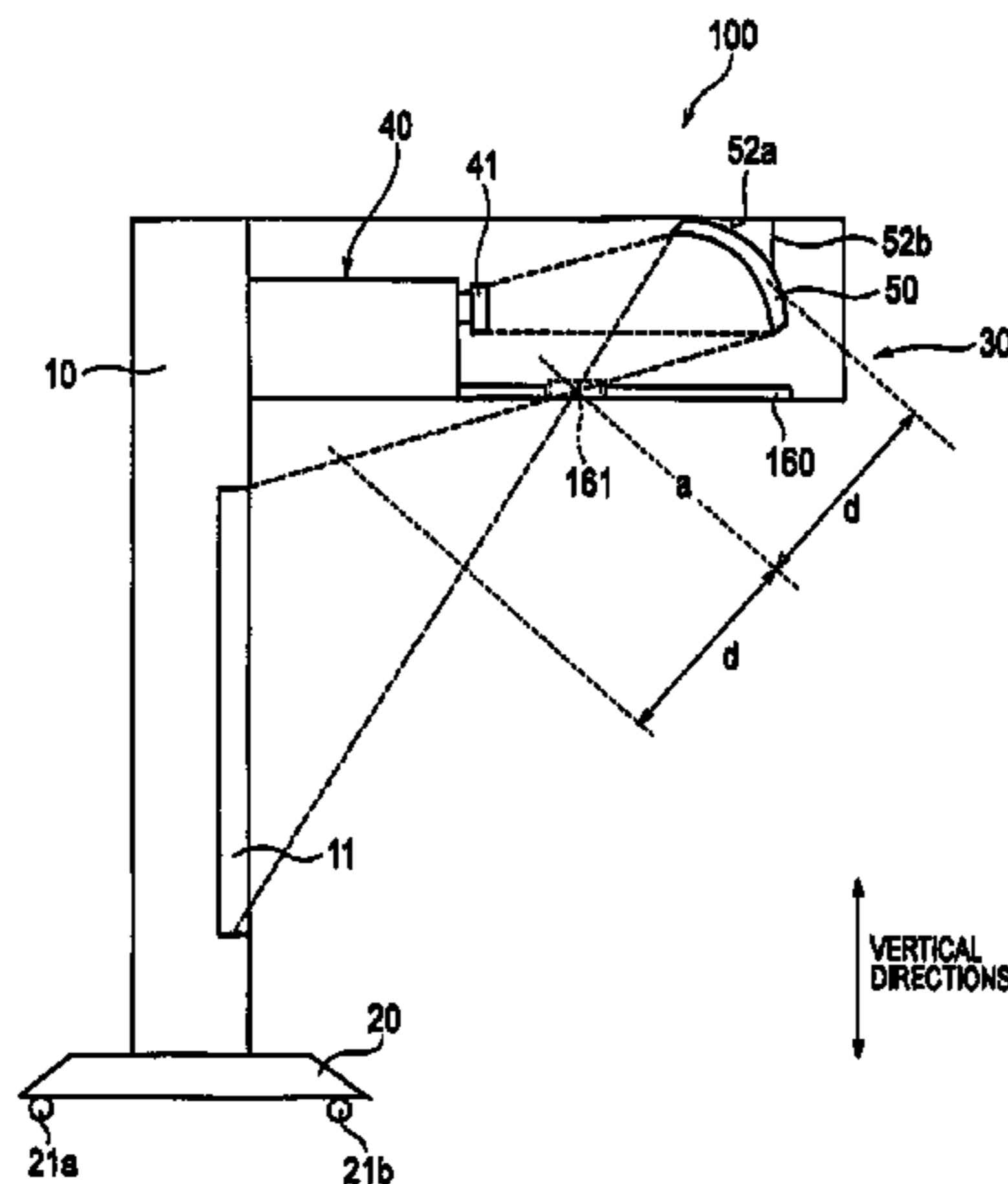


FIG. 1

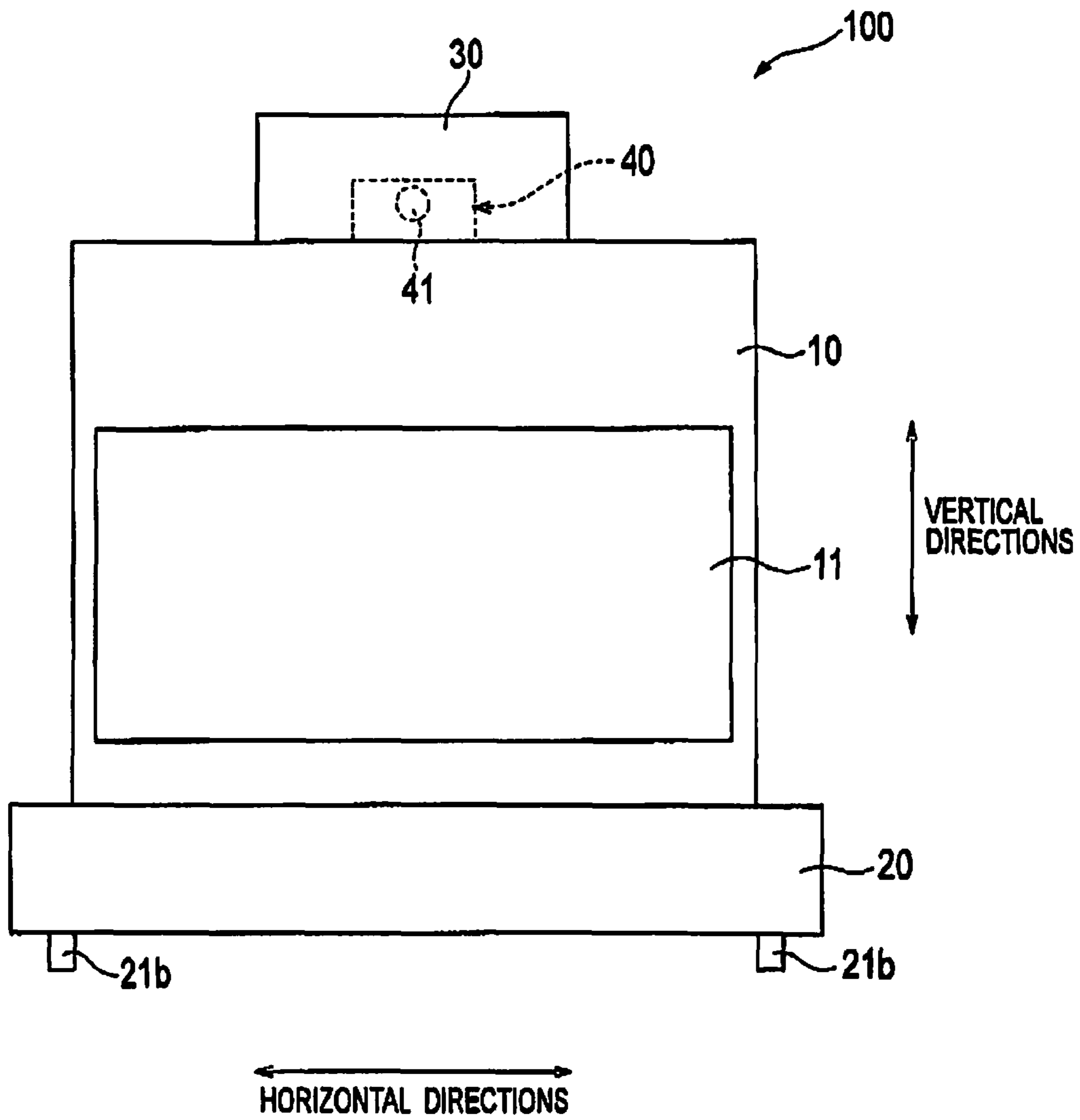


FIG. 2

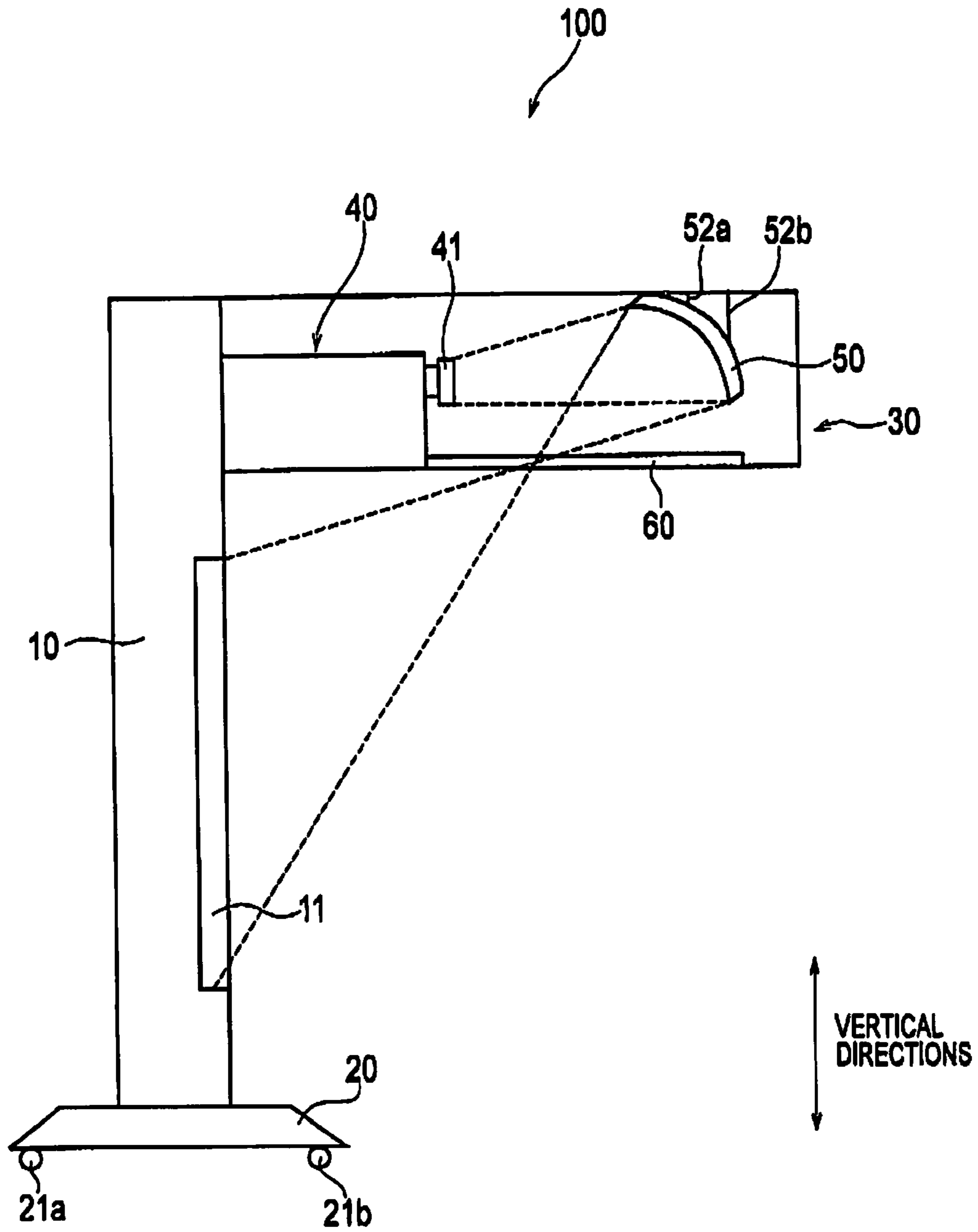


FIG. 3

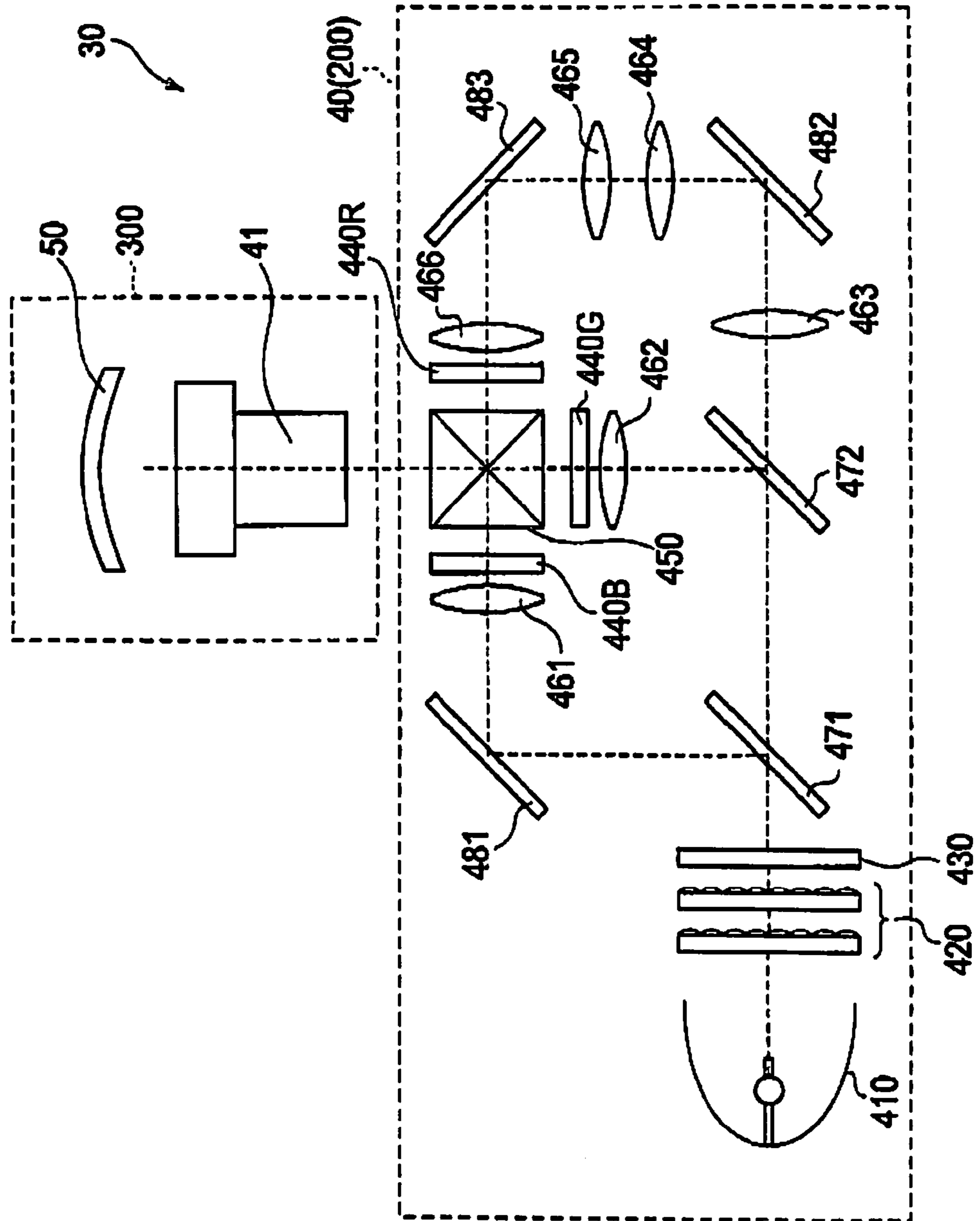


FIG. 4

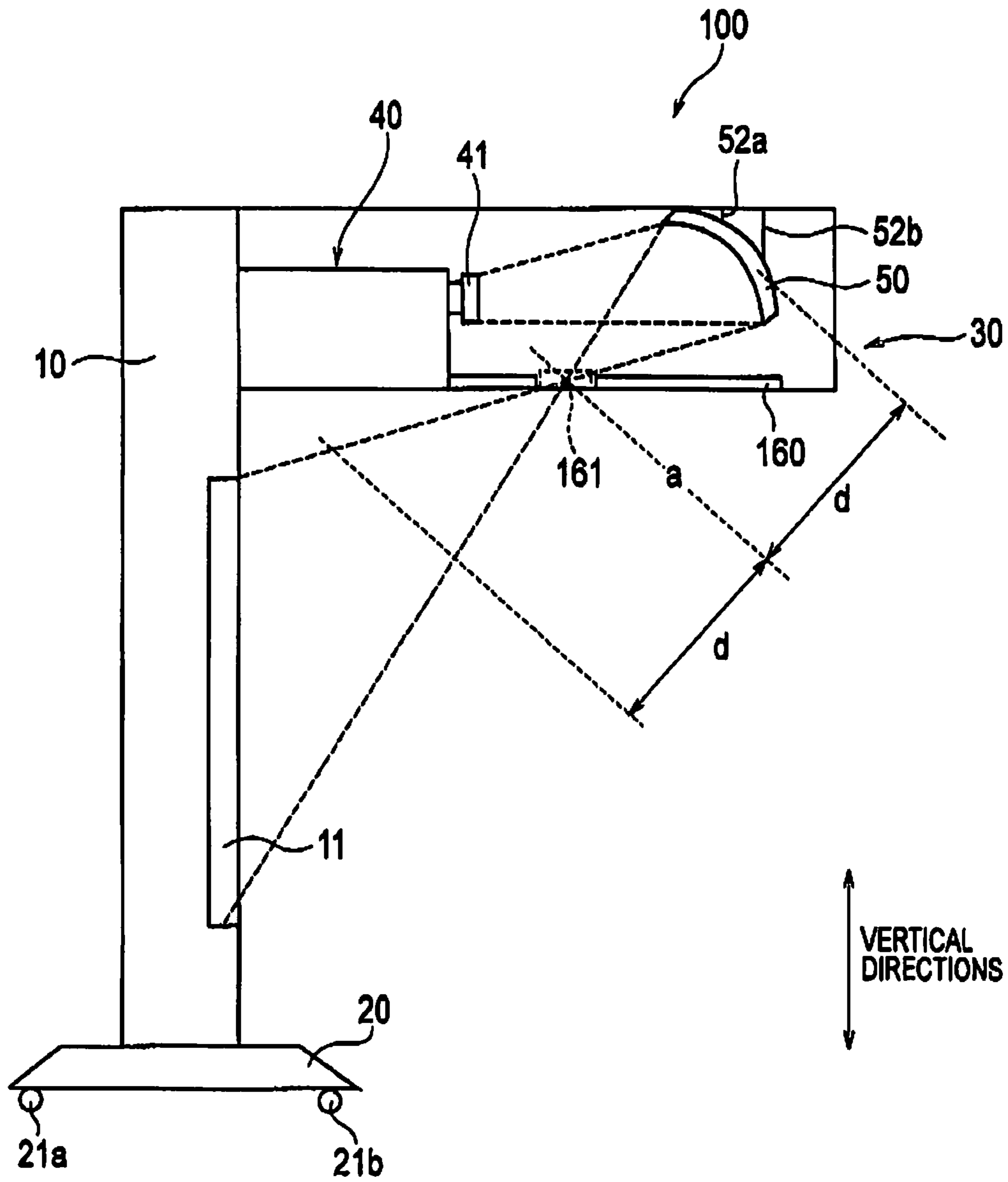


FIG. 5

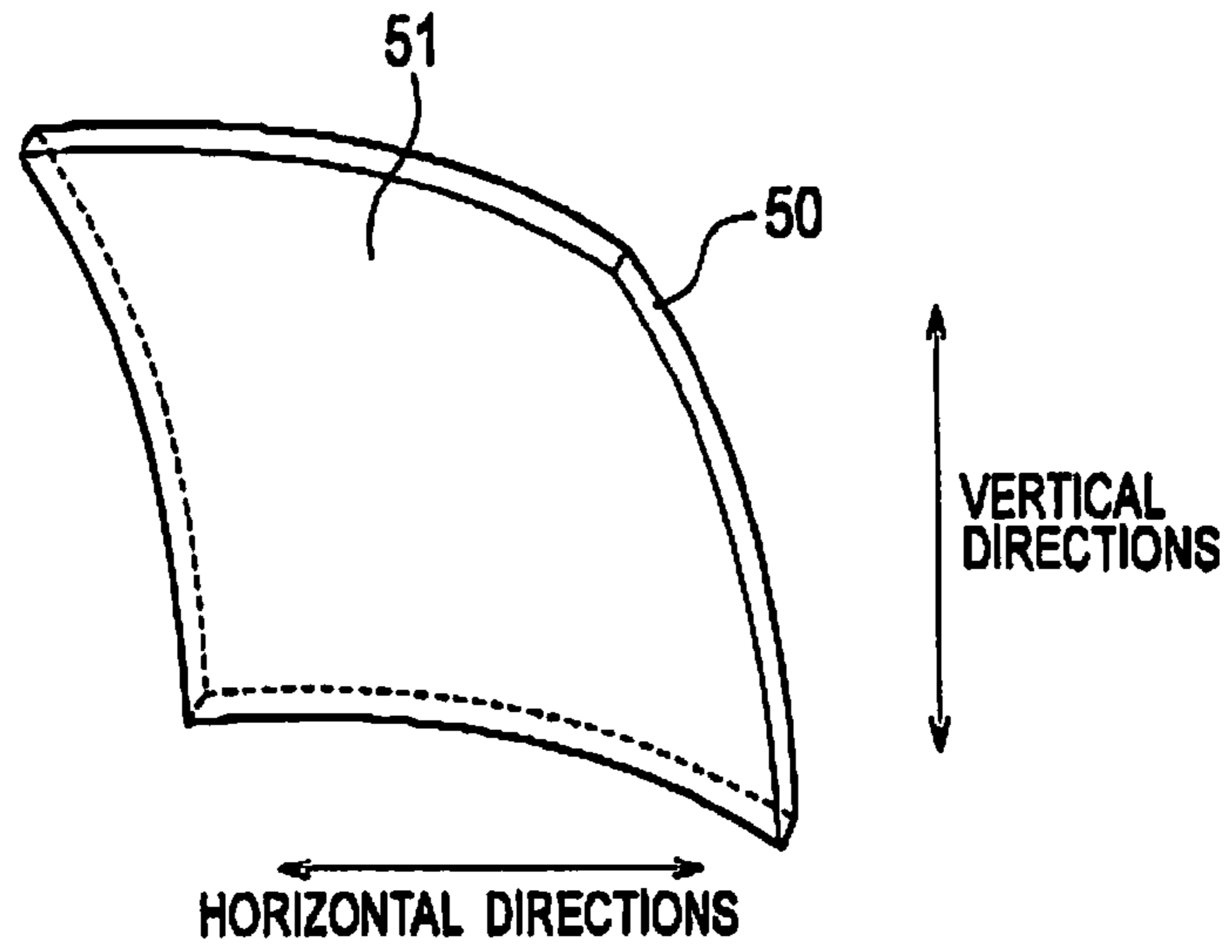


FIG. 6

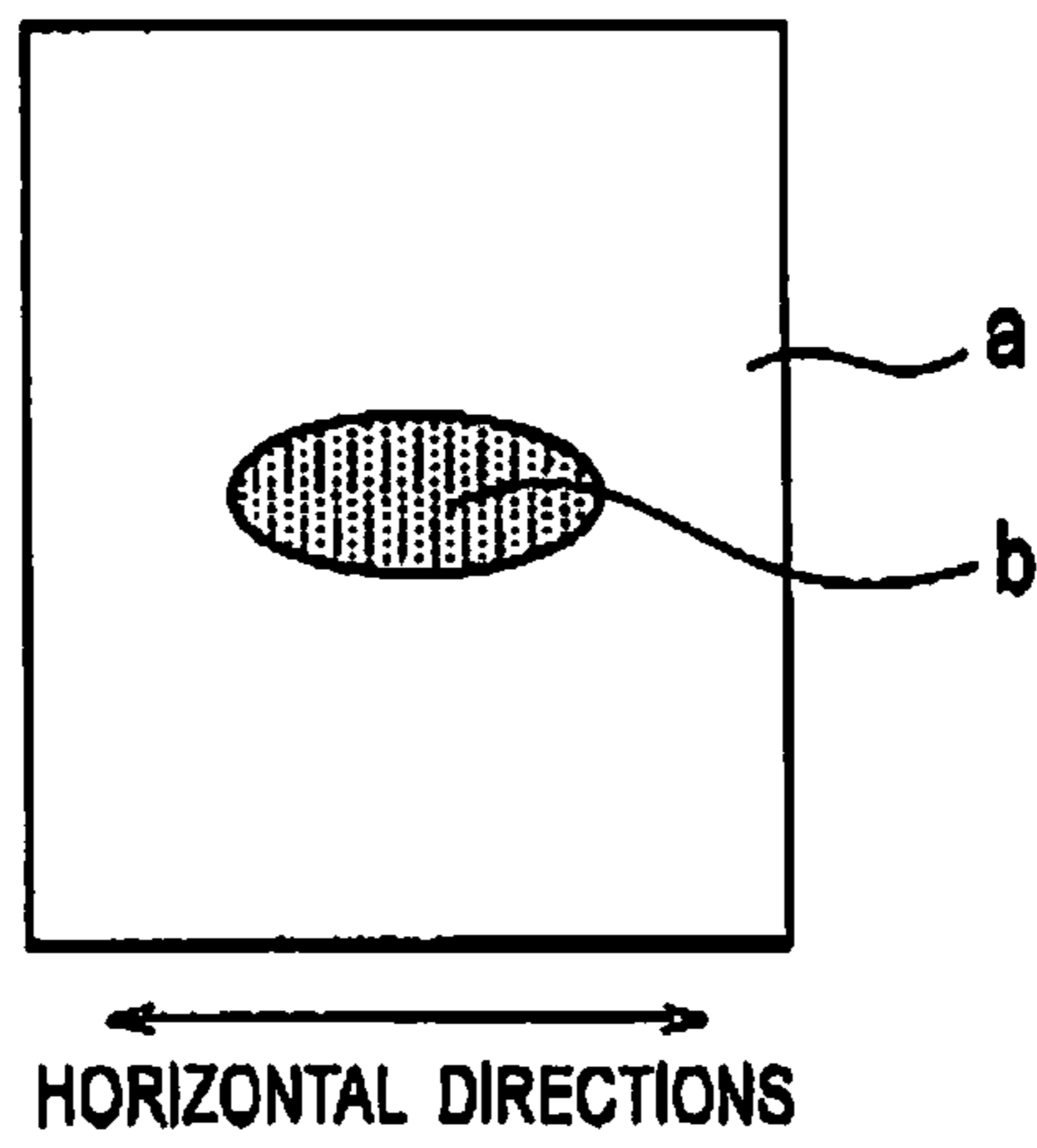


FIG. 7

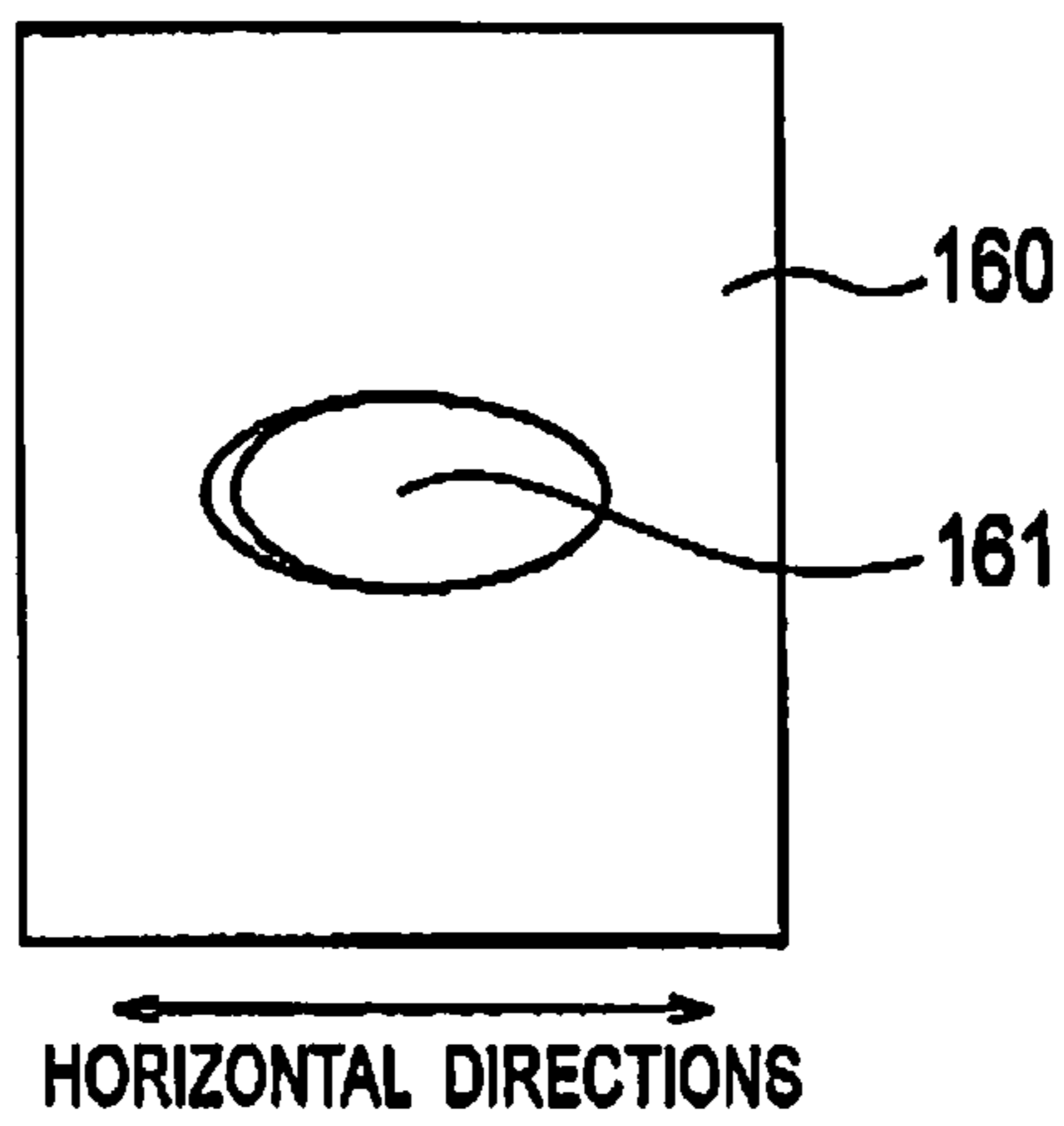


FIG. 8

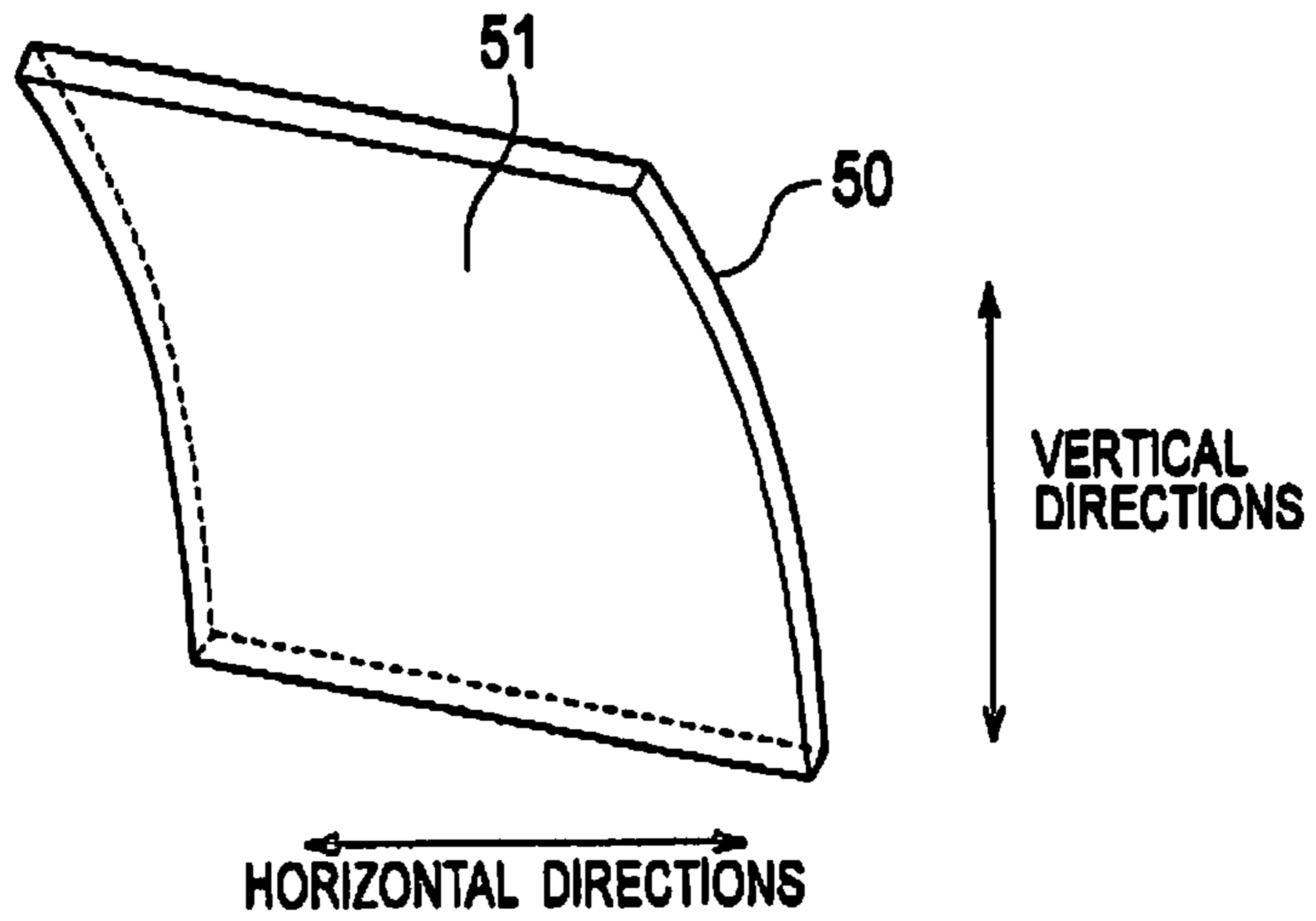


FIG. 9

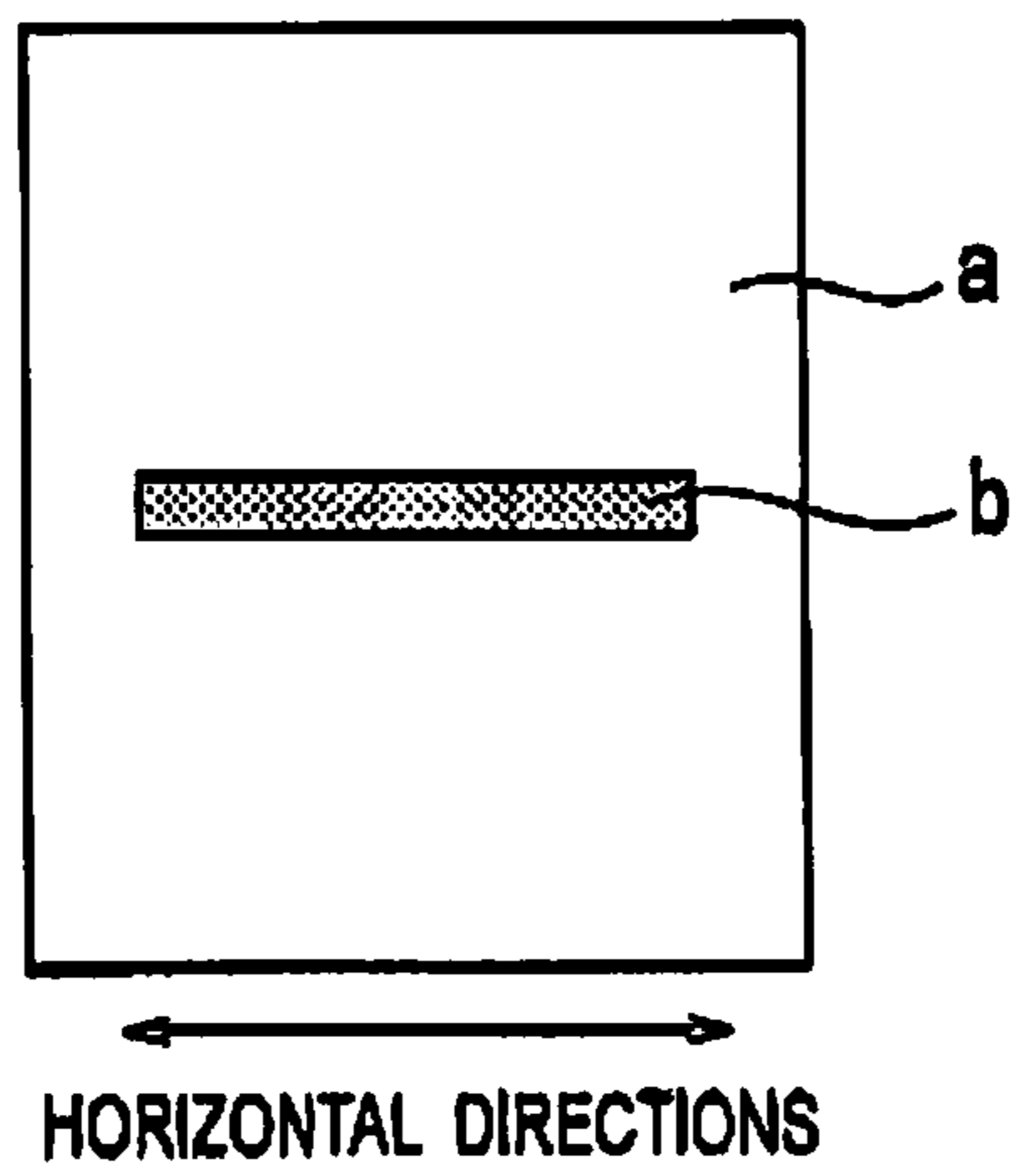


FIG. 10

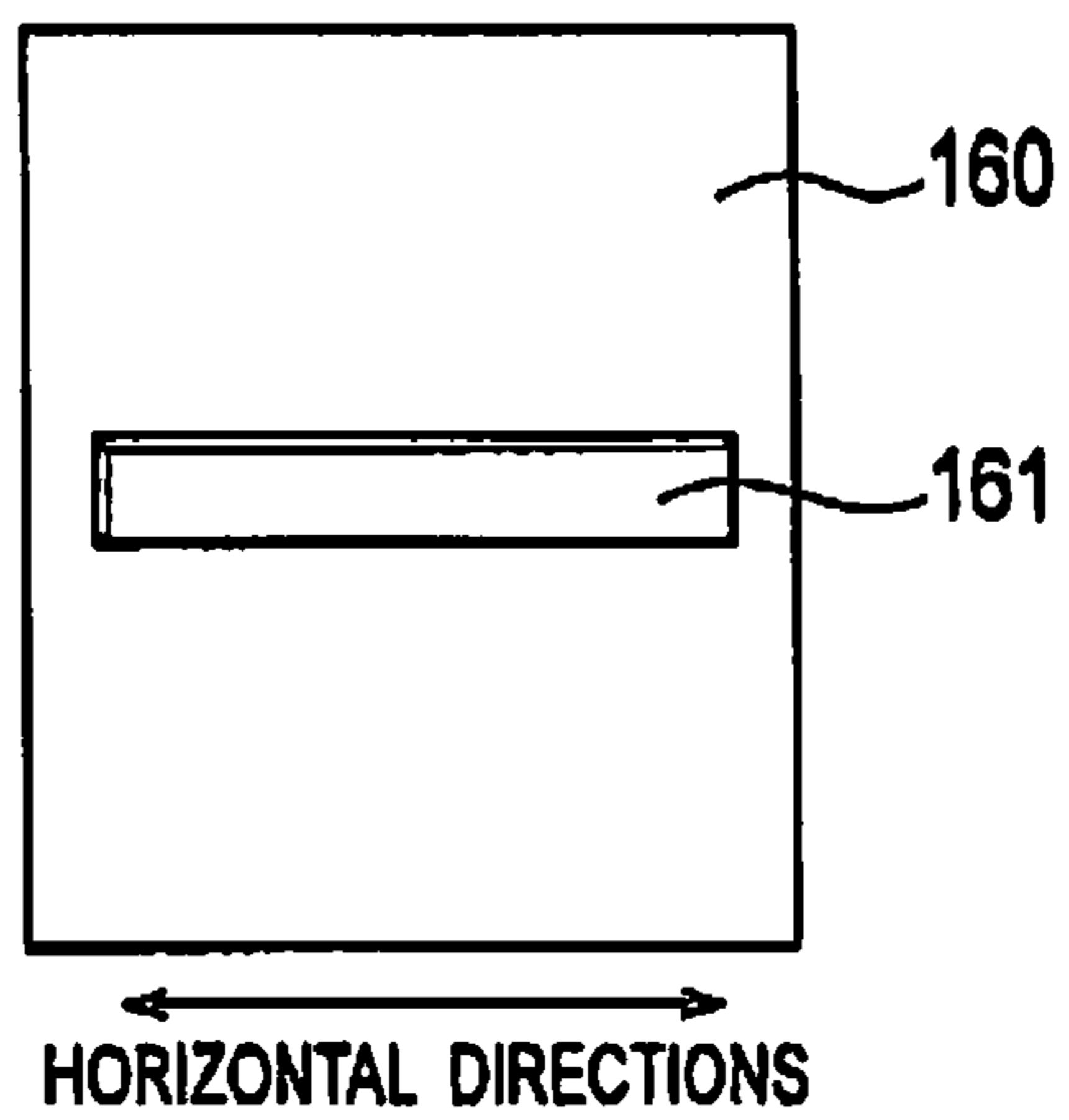


FIG. 11

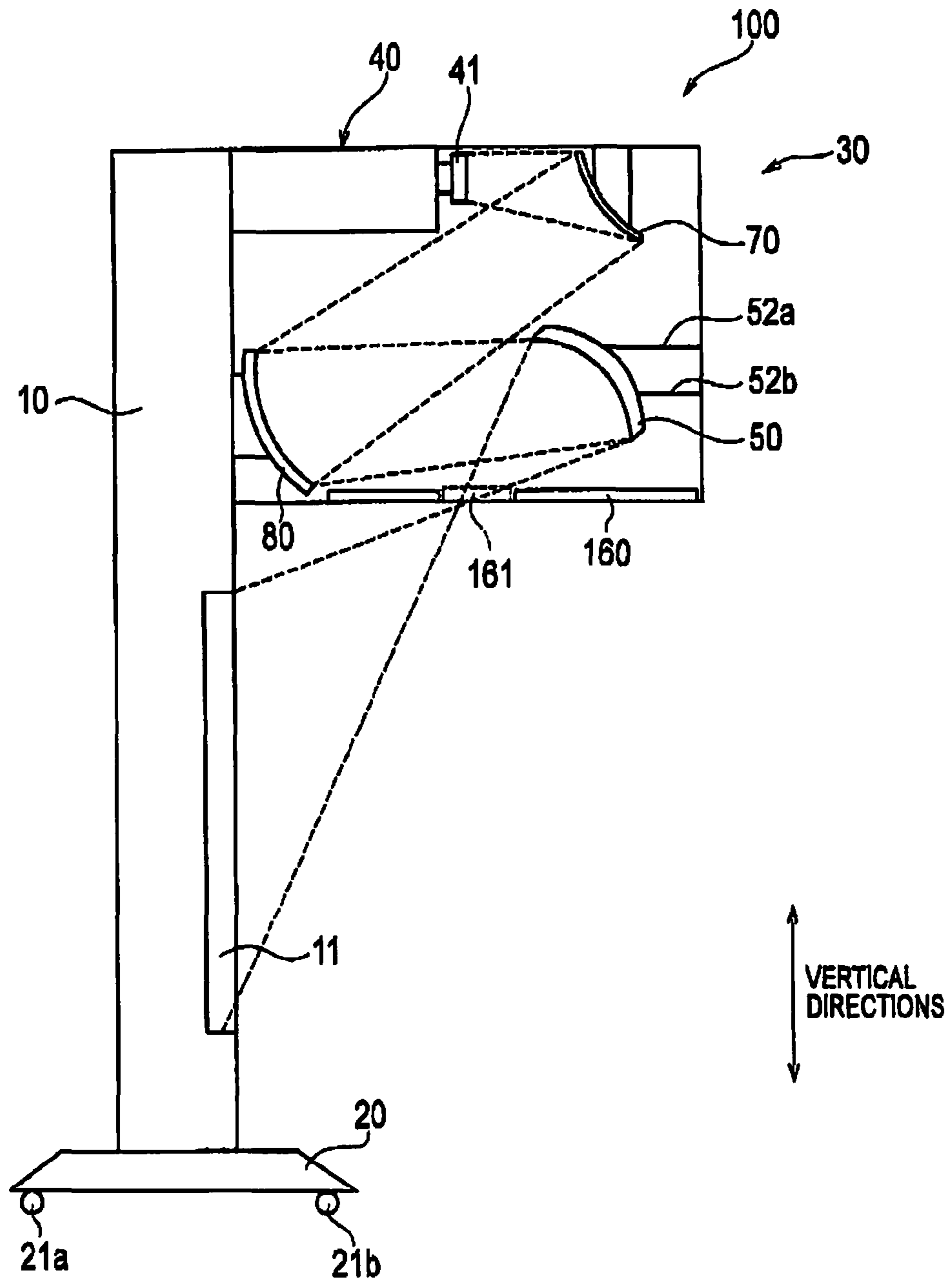




FIG. 12

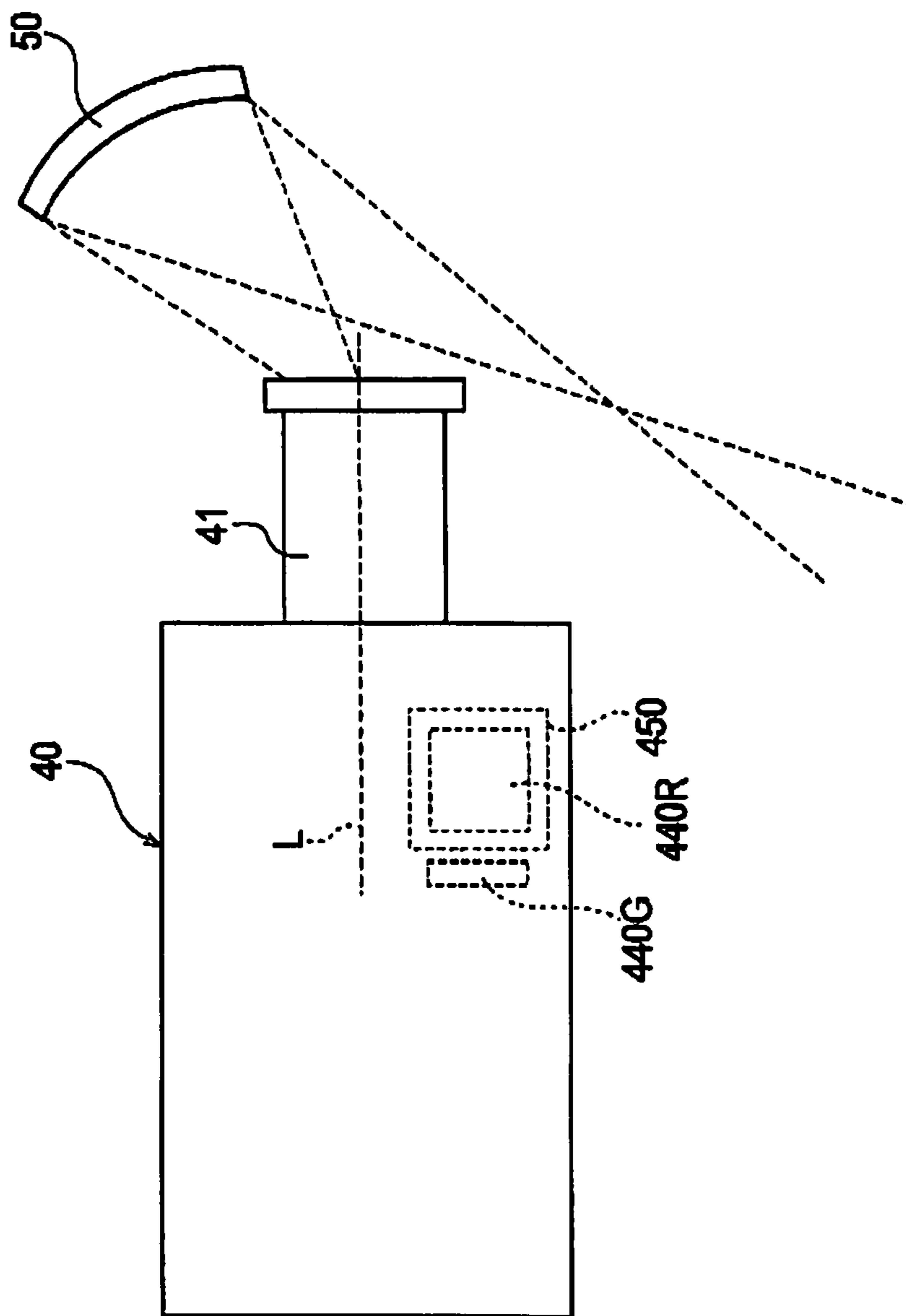


FIG. 13

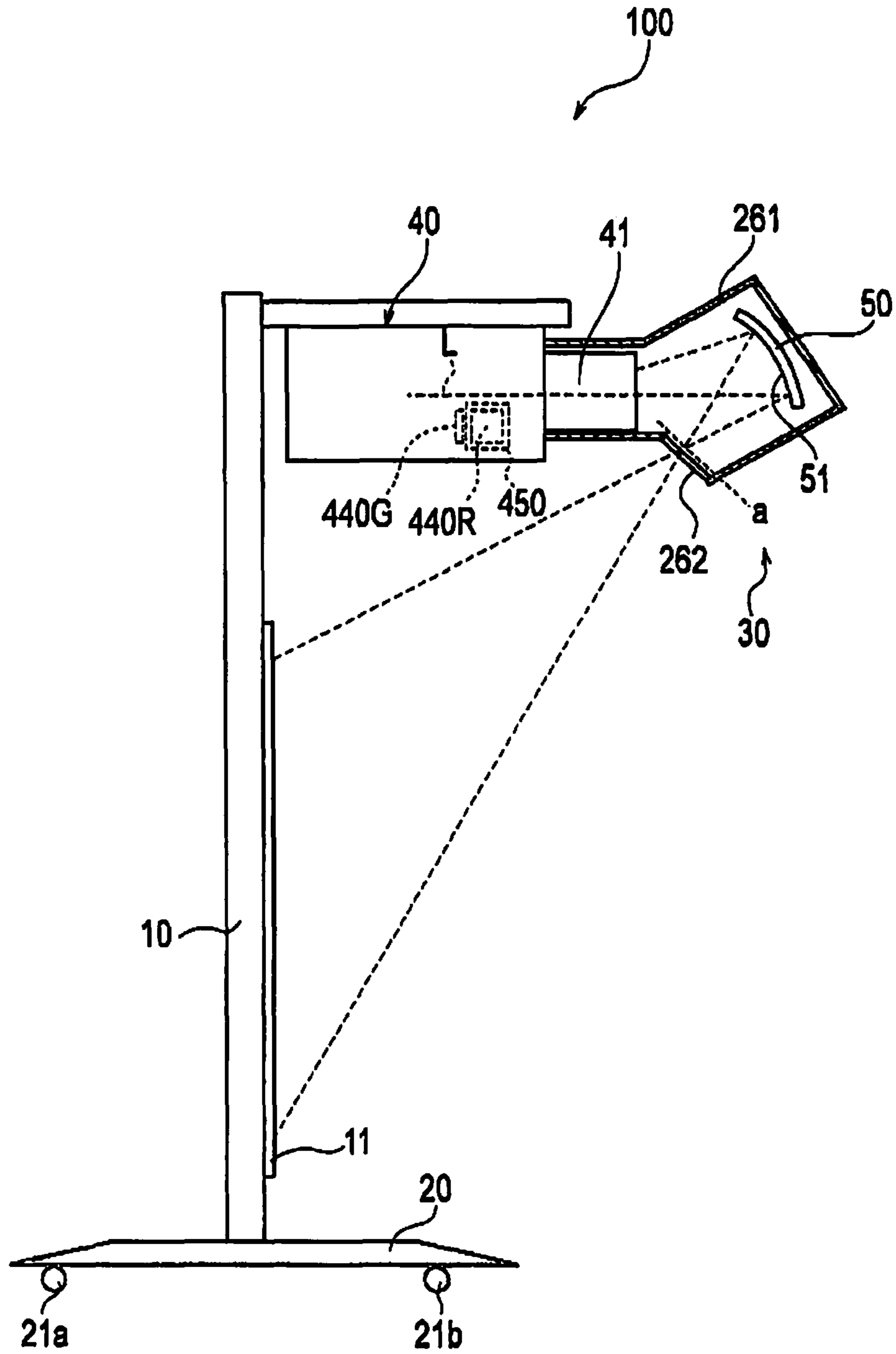


FIG. 14

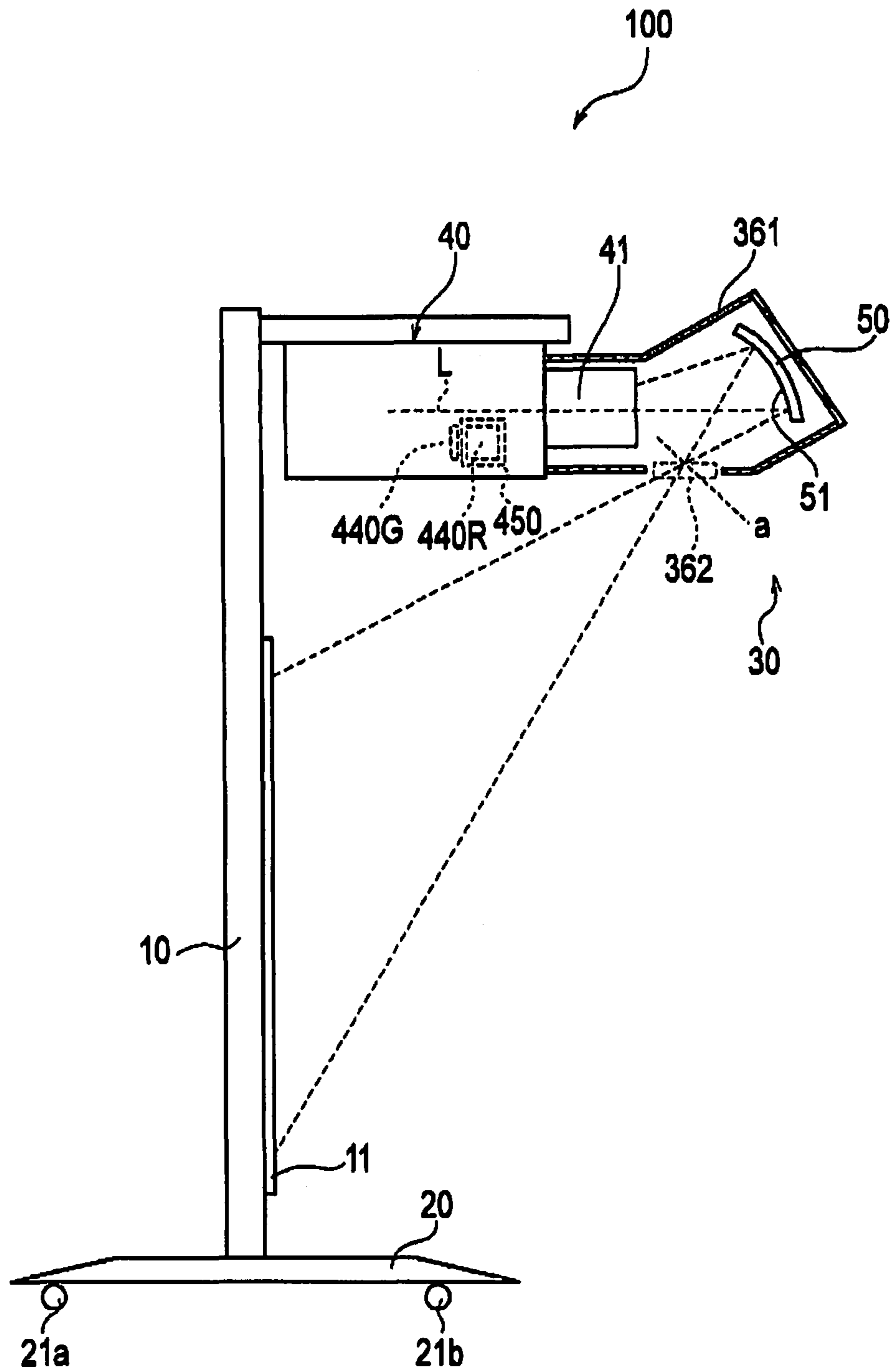


FIG. 15

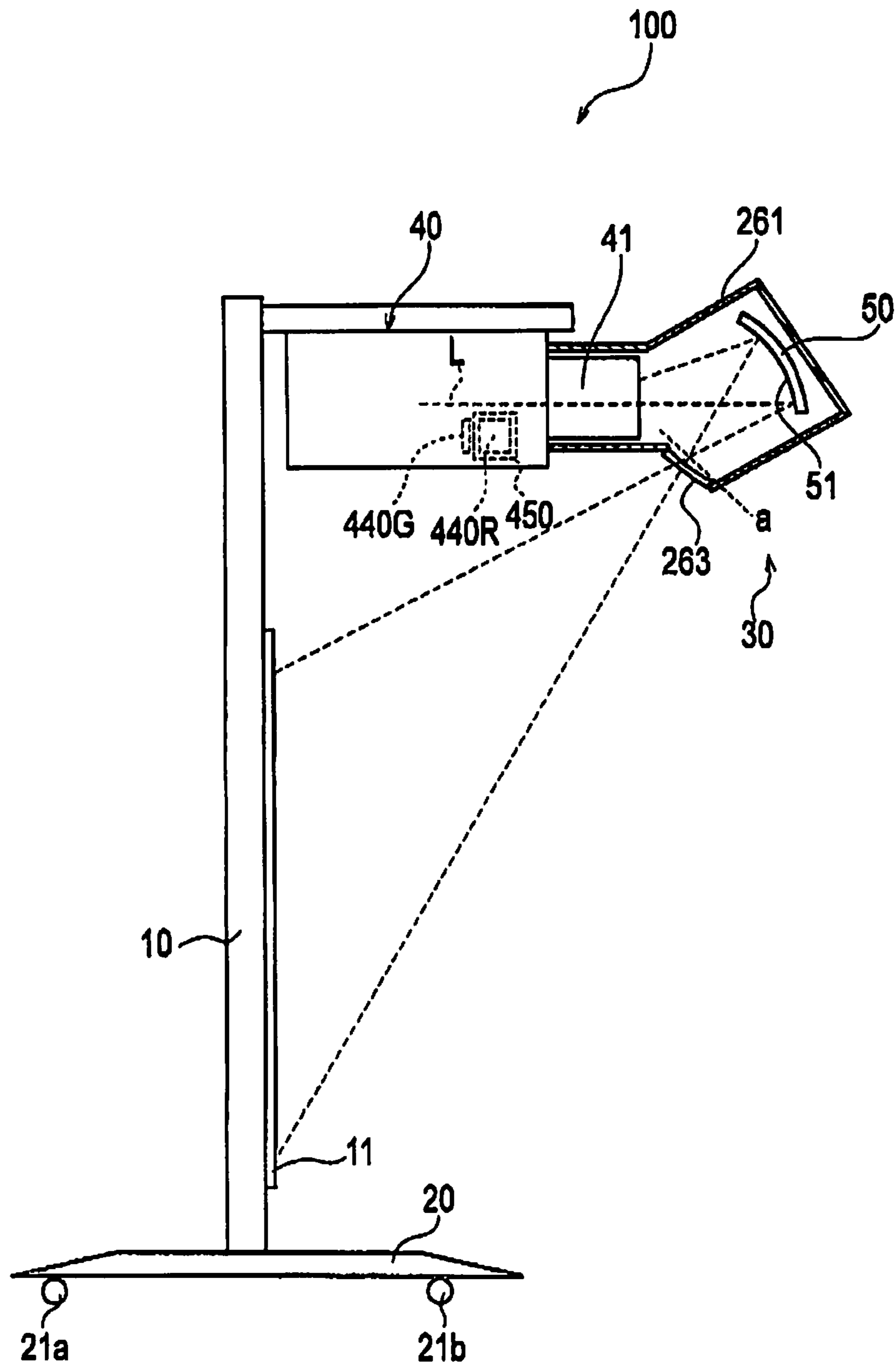
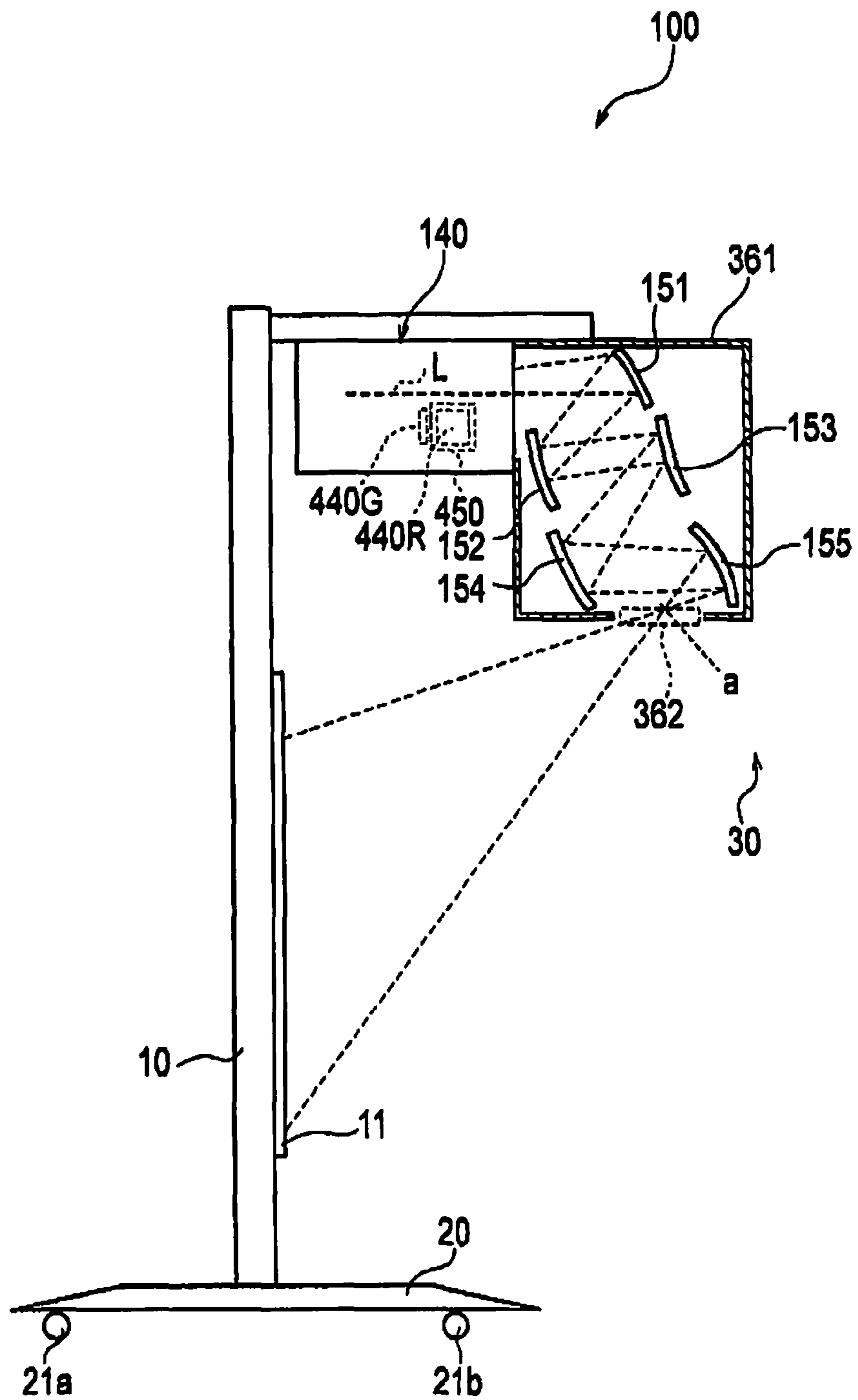


FIG. 16



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**PROJECTION-TYPE IMAGE DISPLAY  
DEVICE AND PROJECTION-TYPE IMAGE  
DISPLAY SYSTEM**

CROSS REFERENCE TO RELATED  
APPLICATIONS

This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2006-269965, filed on Sep. 29, 2006; and Japanese Patent Application No. 2007-228102, filed on Sep. 3, 2007; the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a projection-type image display device and a projection-type image display system, each of which include a projection optics projecting image light onto a screen.

2. Description of the Related Art

Conventionally, there has been known a projection-type image display device having an optical modulator configured to modulate light emitted from a light source and a projection lens configured to project light, which is outputted from the optical modulator onto a screen.

To display a larger image on a screen, it is needed to take a longer distance between the projection lens and the screen. Regarding this background, there has been proposed a projection-type image display system configured to shorten the distance between a projection-type image display device and a screen by utilizing a reflection mirror reflecting light, which is outputted from the projection lens, toward the screen (see, for example, Japanese Patent Publication No. 2004-45894 (claim 1, FIG. 2, and the like)).

When the distance between the projection-type image display device and the screen is shortened, the projection-type image display device comes close to the screen and thus comes into sight of users. For this reason, an oblique projection is needed from an upper, lower, or lateral side of the screen. For example, in the above-mentioned projection-type image display system, positions of the optical modulator and the projection optics are shifted in vertical directions and a convex mirror is used as a reflection mirror, so that a projection distance is shortened and the oblique projection is performed with a shortened projection distance.

In addition, to shorten the distance between the projection-type image display device and the screen, the reflection mirror is disposed in such a position at such an angle that light outputted from the projection lens can obliquely enter the screen. For example, in the above-mentioned projection-type image display system, a convex lens is used as the reflection mirror to shorten the distance between the projection-type image display device and the screen.

To properly display an image on a screen, the positioning of the reflection mirror is an element of substantial importance. Accordingly, when a user touches the reflection mirror, an angle or the like of the reflection mirror is changed, which obstructs proper display of an image to be projected on the screen.

SUMMARY OF THE INVENTION

In an aspect of the present invention, a projection-type image display device (a projection-type image display device 30) includes an image light generator (an image light generator 40), a projection optics (a projection optics 300) having a

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reflection mirror (an aspherical mirror 50), and a protective cover (a protective cover 60). The image light generator generates image light, and the projection optics projects the image light onto a screen (a screen 11). The reflection mirror in the projection optics reflects the image light, which is outputted from the image light generator, toward the screen. The protective cover is provided on an optical path of the image light reflected by the reflection mirror, and has a transmissive region transmitting the image light reflected by the reflection mirror.

According to this aspect, since the protective cover is provided on the optical path of the image light reflected by the reflection mirror, a user is less likely to touch the reflection mirror and change an angle and the like of the reflection mirror. Here, because the protective cover has the transmissive region transmitting the image light reflected by the reflection mirror, the image light to be irradiated on the screen will not be interrupted by the protective cover.

Thus, even when the image light is being projected on the screen, the positioning accuracy of the reflection mirror provided to shorten the distance between the projection-type image display device and the screen can be preferably maintained.

In the above aspect of the present invention, the reflection mirror condenses the image light outputted from the image light generator between the reflection mirror and the screen. The transmissive region of the protective cover is disposed in the vicinity of a position where the image light is condensed by the reflection mirror (a light-condensing surface a).

In the above aspect of the present invention, the protective cover has an opening (an opening 161) communicating from the reflection mirror side to the screen side. The transmissive region is the opening.

In the above aspect of the present invention, at least one portion of the protective cover is formed of a light transmitting member and the transmissive region is formed of the light transmitting member.

In an aspect of the present invention, a projection-type image display system (a projection-type image display system 100) includes a screen (a screen 11), an image light generator (an image light generator 40), a projection optics (a projection optics 300) having a reflection mirror (an aspherical mirror 50), and a protective cover (a protective cover 60). The image light generator generates image light, and the projection optics projects the image light onto the screen. The reflection mirror in the projection optics reflects the image light, which is outputted from the image light generator, toward the screen. The protective cover is provided on an optical path of the image light reflected by the reflection mirror, and has a transmissive region transmitting the image light reflected by the reflection mirror.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view (seen from the front) showing a configuration of a projection-type image display system 100 according to a first embodiment;

FIG. 2 is a view (seen from a side) showing a configuration of the projection-type image display system 100 according to the first embodiment;

FIG. 3 is a view showing a configuration of a projection-type image display device 30 according to the first embodiment;

FIG. 4 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to a second embodiment;

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FIG. 5 is a view showing an aspherical mirror 50 according to the second embodiment;

FIG. 6 is a view showing a light-condensing surface according to the second embodiment;

FIG. 7 is a view showing a protective cover 160 according to the second embodiment;

FIG. 8 is a view showing an aspherical mirror 50 according to a third embodiment;

FIG. 9 is a view showing a light-condensing surface according to the third embodiment;

FIG. 10 is a view showing a protective cover 160 according to the third embodiment;

FIG. 11 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to a fourth embodiment;

FIG. 12 is a view showing a configuration of an image light generator 40 according to a fifth embodiment;

FIG. 13 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to a sixth embodiment;

FIG. 14 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to a seventh embodiment;

FIG. 15 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to an eighth embodiment; and

FIG. 16 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to a ninth embodiment.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

A projection-type image display device according to each embodiment of the present invention will be described below by referring to the drawings. Note that same or similar reference numerals denote same or similar portions in the drawings.

Note that the drawings are merely schematic and proportions of sizes and the like are different from actual ones. Thus, specific sizes and the like should be determined by referring to the description below. In addition, needless to say, portions are included where relationships or proportions of sizes of the drawings differ among the drawings.

##### First Embodiment

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to a first embodiment of the present invention will be described below by referring to the drawings. FIG. 1 is a view (seen from the front) showing a configuration of a projection-type image display system 100 according to the first embodiment. FIG. 2 is a view (seen from a side) showing a configuration of the projection-type image display system 100 according to the first embodiment.

As shown in FIGS. 1 and 2, the projection-type image display system 100 has a body 10, a base 20, and a projection-type image display device 30.

The body 10 has a shape extending in the vertical direction of the projection-type image display system 100. The body 10 has a screen 11 onto which an image is projected.

The base 20 is provided on a lower surface of the body 10 and supports the body 10. The base 20 has wheels 21a and 21b which make the projection-type image display system 100 movable.

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The projection-type image display device 30 has an image light generator 40, a projection lens 41, an aspherical mirror 50, and a protective cover 60. The projection-type image display device 30 is provided on an upper portion of the body 10. Here, the projection lens 41 and the aspherical mirror 50 configure a projection optics 300 as will be described later (see, FIG. 3).

Note that in the first embodiment, the projection-type image display device 30 is provided on an upper portion of the body 10 but the configuration is not limited to this.

Specifically, the projection-type image display device 30 may be provided on a lower portion of the body 10. In this case, the projection-type image display device 30 is disposed upside down.

In addition, the projection-type image display device 30 may be provided in the left or right portion of the body 10. In this case, the projection-type image display device 30 is disposed in a state of being rotated substantially 90°.

As shown in FIG. 3, the projection-type image display device 30 is configured of the image light generator 40 and the projection optics 300. Note that the protective cover 60 is omitted in FIG. 3. The image light generator 40 has a power circuit (not shown) and an image signal processing circuit (not shown) in addition to an optical engine 200.

As shown in FIG. 3, the optical engine 200 has a light source 410, a pair of fly-eye lenses 420, a PBS array 430, a plurality of optical modulators 440 (an optical modulator 440R, an optical modulator 440G, and an optical modulator 440B), and a cross dichroic prism 450.

The light source 410 is a UHP lamp configured of a burner and a reflection mirror.

Each of the fly-eye lenses 420 is formed of a group of minimal lenses and uniform light beams outputted from the light source 410.

The PBS array 430 is an element for aligning the polarization directions of the light beams outputted from the pair of fly-eye lenses 420.

Each of the optical modulators 440 is an element for modulating each color component light based on an image signal. The optical modulator 440 is, for example, a liquid crystal panel.

The cross dichroic prism 450 combines the light beams outputted from each of the optical modulators 440. Specifically, the cross dichroic prism 450 reflects a red component light outputted from the optical modulator 440R and a blue component light outputted from the optical modulator 440B. On the other hand, the cross dichroic prism 450 allows light outputted from the optical modulator 440G to pass through. Note that the light combined by the cross dichroic prism 450 enters the projection lens 41.

The optical engine 200 has a plurality of lens groups (lenses 461 to 466) and a plurality of mirror groups (mirrors 471, 472, and 481 to 483).

The lens 461 is a condenser lens to cause the blue component light to be substantially parallel beams so that the optical modulator 440B would be irradiated with the blue component light. The lens 462 is a condenser lens to cause the green component light to be substantially parallel beams so that the optical modulator 440G would be irradiated with the green component light. The lens 466 is a condenser lens to cause the red component light to be substantially parallel beams so that the optical modulator 440R would be irradiated with the red component light.

The lenses 463 to 465 are relay lenses to adjust a difference between the optical path length of each of the blue component light and the green component light, and the optical path length of the red component light.

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The mirror **471** is a dichroic mirror to reflect the blue component light and to transmit the red component light and the green component light. The mirror **472** is a dichroic mirror to reflect the green component light and to transmit the red component light.

The mirror **481** is a mirror to reflect the blue component light to lead the blue component light to the optical modulator **440B**. The mirrors **482** and **483** are mirrors to reflect the red component light to lead the red component light to the optical modulator **440R**.

Note that in the first embodiment, the UHP lamp is used as the light source **410**, but the configuration is not limited to this. Specifically, a solid light source such as an LED (a light emitting diode) or an LD (a laser diode) may be used as the light source **410**. In this case, it is also possible that a configuration of an optical system does not include fly-eye lenses **420**, a PBS array **430**, a plurality of lens groups, and a plurality of mirror groups.

As shown in FIG. 3, the projection optics **800** has the projection lens **41** and the aspherical mirror **50**. The projection lens **41** outputs the light (the image light) combined by the cross dichroic prism **450** provided in the optical engine **200**, to the aspherical mirror **50** side. The aspherical mirror **50** causes the image light outputted from the projection lens **41** to have a wider angle and reflects the image light to the screen **11** side.

The aspherical mirror **50** is attached to arm members **52a** and **52b** which are fixed on a wall surface of the projection-type image display device **30**. The aspherical mirror **50** is an aspherical mirror to condense light outputted from the projection lens **41** and to reflect the light to the screen **11** side.

Note that in the first embodiment, the mirror provided in a rear stage of the projection optics **300** is the aspherical mirror **50** but is not limited to this. Specifically, the mirror provided in the rear stage of the projection optics **300** may be a free-form surface mirror.

Returning to FIG. 2, the protective cover **60** is provided on the optical path of the image light reflected by the aspherical mirror **50**. Specifically, the protective cover **60** is provided beneath the projection-type image display device **30** and covers a lower portion of the aspherical mirror **50** so as to prevent the aspherical mirror **50** from being touched by a user. The protective cover **60** is formed of a light transmitting member such as a transparent resin or a glass and transmits the image light reflected by the aspherical mirror **50**.

Here, since optical characteristics (such as a refractive index) of the image light irradiated onto the screen **11** vary depending on the kind of the light transmitting member forming the protective cover **60**, it is preferable that an optical design for the projection optics **300** be made in consideration of the kind of the light transmitting member forming the protective cover **60**.

(Advantageous Effects)

According to the projection-type image display device **30** of the first embodiment, the protective cover **60** is provided on the optical path of the image light reflected by the aspherical mirror **50**. Thus, the user is less likely to touch the aspherical mirror **50** to cause any change in an angle of the aspherical mirror **50** or the like. Since the protective cover **60** is formed of the light transmitting member transmitting the image light reflected by the aspherical mirror **50**, the image light irradiating onto the screen **11** is not interrupted by the protective cover **60**. Accordingly, positioning accuracy of the reflection mirror provided to shorten the distance between the projection-type image display device **30** and the screen **11** can be preferably maintained.

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## Second Embodiment

A second embodiment of the present invention will be described below by referring to the drawings. In the following, differences between the first embodiment and the second embodiment will be described by referring to the drawings.

Specifically, in the above-mentioned first embodiment, the protective cover **60** protecting the aspherical mirror **50** is formed of the light transmitting member. In contrast, in the second embodiment, a protective cover **160** has an opening through which image light condensed by an aspherical mirror **50** passes. Note that the protective cover **160** does not need to be formed of a light transmitting member.

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the second embodiment of the present invention will be described below by referring to the drawings. FIG. 4 is a view showing a configuration of a projection-type image display system **100** according to the second embodiment. Note that in FIG. 4, similar reference numerals are given to denote components similar to those of FIG. 2. As shown in FIG. 4, the projection-type image display system **100** has a protective cover **160** in place of a protective cover **60**.

(Configurations of an Aspherical Mirror and a Protective Cover)

Configurations of an aspherical mirror and a protective cover according to the second embodiment will be described below by referring to FIGS. 5 to 7.

As shown in FIG. 5, an aspherical mirror **50** is a mirror having a curved surface **51** which is curved in horizontal directions and in vertical directions of a projection-type image display system **100**. Image light reflected by the curved surface **51** of the aspherical mirror **50** is projected onto a screen **11** after being condensed on a light-condensing surface **a**. The light-condensing surface **a** is a surface where the broadening of a light flux of the image light becomes the smallest.

Specifically, as shown in FIG. 6, on the light-condensing surface **a**, the image light reflected by the curved surface **51** of the aspherical mirror **50** is condensed in a region **b** having a particular shape depending on a shape of the curved surface **51** of the aspherical mirror **50**. Note that in FIG. 6, the region **b** is shown as a region having an elliptic shape for simplicity, but the actual shape of the region **b** becomes a more complicated shape.

The protective cover **160** has an opening **161** communicating from an aspherical mirror **50** side to a screen **11** side. The image light reflected by the curved surface **51** of the aspherical mirror **50** is irradiated onto the screen **11** through the opening **161** provided in the protective cover **160**.

Specifically, as shown in FIG. 7, the protective cover **160** is provided with the opening **161** depending on a particular shape of the image light condensed in the region **b**. A size of the opening **161** is at least larger than that of the region **b** in which the image light is condensed on the light-condensing surface **a**. However, as long as the image light reflected by the curved surface **51** of the aspherical mirror **50** is transmittable, a shape of the opening **161** can be any shape.

In addition, it is preferable that the opening **161** be provided in the vicinity of the light-condensing surface **a** to minimize the size of the opening **161**. Here, the vicinity of the light-condensing surface **a** means that a distance from the light-condensing surface **a** is in a range of "d". Here, "d" indicates a distance between the aspherical mirror **50** and the light-condensing surface **a** on a main light beam of light beams passing through the centers of optical modulators **440**.



(Advantageous Effects)

According to the projection-type image display device **30** of the second embodiment, the aspherical mirror **50** condenses the image light outputted from the projection lens **41** in the region **b** on the light-condensing surface **a**. Thus, the opening **161** provided in the protective cover **160** can be minimized. Therefore, even when the opening **161** is provided in the protective cover **160**, a possibility of a user touching the aspherical mirror **50** can be reduced.

In addition, in a case where a transmissive region of the protective cover **160** is formed of a light transmitting member, an optical design for a projection optics **300** has to be made depending on the kind of the light transmitting member. In contrast, according to the projection-type image display device **30** of the second embodiment, the transmissive region of the protective cover **160** is the opening **161**, and there is no need to consider the kind of the light transmitting member. Thus, the optical design for the projection optics **300** is made easier.

#### Third Embodiment

A third embodiment of the present invention will be described below by referring to the drawings. The description will be mainly given to differences between the above-mentioned second embodiment and the third embodiment.

Specifically, in the above-mentioned second embodiment, the aspherical mirror **50** is a mirror having the curved surface **51** which is curved in the vertical directions and in the horizontal directions of the projection-type image display system **100**. In contrast, in the third embodiment, an aspherical mirror **50** is a mirror having a curved surface **51** which is only curved in vertical directions of a projection-type image display system **100**.

In addition, in the above-mentioned second embodiment, the protective cover **160** is provided with the opening **161** having a particular shape depending on a shape of the curved surface **51** of the aspherical mirror **50**. In contrast, a protective cover **160** of the third embodiment is provided with an opening **161** having a long rectangular shape in horizontal directions of the projection-type image display system **100**.

(Configurations of an Aspherical Mirror and a Protective Cover)

Configurations of an aspherical mirror and a protective cover according to the third embodiment will be described below by referring to FIGS. **8** to **10**.

As shown in FIG. **8**, the aspherical mirror **50** is a mirror having a curved surface **51** which is only curved in vertical directions of the projection-type image display system **100**. Similar to the second embodiment, image light reflected by the curved surface **51** of the aspherical mirror **50** is projected onto a screen **11** after being condensed on a light-condensing surface **a**.

Specifically, as shown in FIG. **9**, on the light-condensing surface **a**, the image light reflected by the curved surface **51** of the aspherical mirror **50** is condensed in a region **b** having a particular shape depending on a shape of the curved surface **51** of the aspherical mirror **50**. Note that in FIG. **9**, the region **b** is shown as a region having a long rectangular shape in horizontal directions of the projection-type image display system **100** for simplicity, but the actual shape of the region **b** becomes a more complicated shape.

Similar to the second embodiment, the protective cover **160** has an opening **161** communicating from an aspherical mirror **50** side to a screen **11** side. The image light reflected by

the curved surface **51** of the aspherical mirror **50** is irradiated onto the screen **11** through the opening **161** provided in the protective cover **160**.

Specifically, as shown in FIG. **10**, the protective cover **160** is provided with an opening **161** having a long rectangular shape in horizontal directions of the projection-type image display system **100**. A size of the opening **161** is at least larger than that of the region **b** in which the image light is condensed on the light-condensing surface **a**. However, as long as the image light reflected by the curved surface **51** of the aspherical mirror **50** is transmittable, a shape of the opening **161** can be any shape.

#### Fourth Embodiment

A fourth embodiment of the present invention will be described below by referring to the drawings. In the following, the description will be mainly given to differences between the above-mentioned second embodiment and the fourth embodiment.

Specifically, in the above-mentioned second embodiment, the image light outputted from the projection lens **41** is reflected only once. In contrast, the image light outputted from a projection lens **41** of the fourth embodiment is reflected for a plurality of times (three times).

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the fourth embodiment will be described below by referring to the drawings. FIG. **11** is a view (seen from a side) showing a configuration of a projection-type image display system **100** according to the fourth embodiment. Note that in FIG. **11**, similar reference numerals are given to denote components similar to those of FIG. **2**.

As shown in FIG. **11**, the projection-type image display system **100** has reflection mirrors **70** and **80** in addition to the configuration of FIG. **2**.

The reflection mirror **70** is a convex mirror reflecting image light outputted from a projection lens **41** to the reflection mirror **80** side. In addition, since the reflection mirror **70** is a convex mirror, the image light outputted from the projection lens **41** is enlarged. The reflection mirror **80** is a concave mirror reflecting the image light reflected by the reflection mirror **70** to an aspherical mirror **50** side. Note that the projection lens **41**, the reflection mirrors **70** and **80**, and the aspherical mirror **50** configure a projection optics.

(Advantageous Effect)

According to a projection-type image display device **30** of the fourth embodiment, the image light outputted from the projection lens **41** is reflected not only by the aspherical mirror **60** but also by the reflection mirrors **70** and **80**. Thus, even if a size in a depth direction of the projection-type image display device **30** is set to be small, the projection-type image display device **30** can sufficiently enlarge and project the image light outputted from the projection lens **41** on a screen **11**.

#### Fifth Embodiment

A fifth embodiment of the present invention will be described below by referring to the drawings. In the following, the description will be mainly given to differences between the above-mentioned first embodiment and the fifth embodiment.

Specifically, in the fifth embodiment, an effective display region of a modulator **440** is provided in a portion lower than a projection lens **41**, which is not particularly mentioned in the first embodiment.

(Configuration of an Image Light Outputting Device)

A configuration of an image light outputting device according to the fifth embodiment will be described below by referring to the drawings. FIG. 12 is a view showing a configuration of an image light generator 40 according to the fifth embodiment. Here, the image light generator 40 has a configuration similar to that of FIG. 3. Note that in FIG. 12, only components necessary for the description of the fifth embodiment are shown.

As shown in FIG. 12, in the image light generator 40, an effective display region of an optical modulator 440 is provided in a portion lower than a projection lens 41. Specifically, the effective display region of the optical modulator 440 is provided in a portion lower than the center L of an optical axis of the projection lens 41.

With this, the image light outputted from the projection lens 41 is outputted obliquely upward from the projection lens 41. Thus, an aspherical mirror 50 reflecting the image light outputted from the projection lens 41 to a screen 11 (not shown in FIG. 12) side is provided in a position obliquely upward of the projection lens 41.

(Advantageous Effects)

According to the fifth embodiment, the effective display region of the optical modulator 440 is provided in a portion lower than the projection lens 41. Thus, the image light outputted from the projection lens 41 is outputted obliquely upward from the projection lens 41. Accordingly, wider oblique projection can be achieved, so that the distance between the projection-type image display device and the screen can be further shortened.

#### Sixth Embodiment

A sixth embodiment of the present invention will be described below by referring to the drawings. The sixth embodiment is a combination of the first and fifth embodiments.

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the sixth embodiment will be described below by referring to the drawings. FIG. 13 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to the sixth embodiment. Note that in FIG. 13, similar reference numerals are given to denote components similar to those of FIG. 2.

As shown in FIG. 13, in the projection-type image display system 100, protective covers 261 and 262 are provided so as to cover a projection lens 41 and an aspherical mirror 50. The protective cover 262 is provided in the vicinity of a light-condensing surface a and is formed of a light transmitting member. The protective cover 262 has a shape capable of transmitting a light flux having a particular shape, which is condensed depending on the form of a curved surface 61 of the aspherical mirror 50. However, as long as image light reflected by the curved surface 51 of the aspherical mirror 50 is transmittable, the shape of the protective cover 262 can be any shape.

As a matter of course, the protective cover 261 does not need to be formed of a light-transmitting member. The aspherical mirror 50 is held inside the protective cover 261 by a holding mechanism provided inside the protective cover 261.

#### Seventh Embodiment

A seventh embodiment of the present invention will be described below by referring to the drawings. The seventh embodiment is a combination of the second and fifth embodiments.

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the seventh embodiment will be described below by referring to the drawings. FIG. 14 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to the seventh embodiment. Note that in FIG. 14, similar reference numerals are given to denote components similar to those of FIG. 4.

As shown in FIG. 14, in the projection-type image display system 100, a protective cover 361 is provided so as to cover a projection lens 41 and an aspherical mirror 50. The protective cover 361 has an opening 862 in the vicinity of a light-condensing surface a. The opening 362 has a shape capable of transmitting a light flux having a particular shape, which is condensed depending on the form of a curved surface 51 of the aspherical mirror 50. However, as long as image light reflected by the curved surface 51 of the aspherical mirror 50 is transmittable, the shape of the opening 362 can be any shape.

The aspherical mirror 50 is held inside the protective cover 361 by a holding mechanism provided inside the protective cover 361.

#### Eighth Embodiment

An eighth embodiment of the present invention will be described below by referring to the drawings. In the following, the description will be mainly given to differences between the above-mentioned sixth embodiment and the eighth embodiment.

Specifically, in the above-mentioned sixth embodiment, the protective cover 262 formed of a light-transmitting member is provided in the vicinity of the light-condensing surface a. In contrast, in the eighth embodiment, a concave lens for projecting image light with a more wider angle is provided in the vicinity of the light-condensing surface a. Specifically, it is preferable that the concave lens be disposed on a side between the light condensing surface a and the screen 11, within a range "d" that extends on either side of the light-condensing surface a.

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the eighth embodiment will be described below by referring to the drawings. FIG. 15 is a view (seen from a side) showing a configuration of a projection-type image display system 100 according to the eighth embodiment. Note that in FIG. 15, similar reference numerals are given to denote components similar to those of FIG. 13.

As shown in FIG. 15, in the projection-type image display system 100, a concave lens 263 is provided in place of a protective cover 262 formed of a light-transmitting member.

The concave lens 263 is provided in the vicinity of the light-condensing surface a. Specifically, the concave lens 263 is disposed on a side between the light condensing surface a and the screen 11, within a range "d" that extends on either side of the light-condensing surface a. The concave lens 263 is configured so as to condense image light reflected by an aspherical mirror 50. The concave lens 263 preferably has a concave surface on the aspherical mirror 50 side, and plane surface on the screen 11 side. The projection optics is preferably surrounded with the protective cover 261 of flat shape. That is, the projection optics is surrounded with the plane surface provided on the concave lens 263 and the protective cover 261 of flat shape. Therefore, accumulation of dusts on the exterior surface of the protective cover 261 and the concave lens 263 may be suppressed.

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In the eighth embodiment, a projection lens **41**, the aspherical mirror **50** and the concave lens **263** configure a projection optics **300** projecting the image light onto the screen **11**.

In addition, in the eighth embodiment, the concave lens **263** is used in place of the protective cover **262**, but the configuration is not limited to this. Specifically, an aspherical lens or a free-form surface lens may be used in place of the protective cover **262**.

In this manner, since the concave lens **263** is provided in the vicinity of the light-condensing surface *a*, the distance between a projection-type image display device and the screen can be further shortened when compared with the distance in the sixth embodiment.

the concave lens **263** is disposed on a side between the light condensing surface *a* and the screen **11**, within a range “*d*” that extends on either side of the light-condensing surface *a*. That is, the concave lens **263** condenses re-scattered image light after the image light is condensed on the light-condensing surface *a*. Thus, an effect of a wider angle by use of the concave lens **263** can be further achieved.

## Ninth Embodiment

A ninth embodiment of the present invention will be described below by referring to the drawings. In the following, the description will be mainly given to differences between the above-mentioned seventh embodiment and the ninth embodiment.

Specifically, in the above-mentioned seventh embodiment, the projection optics **300** is configured of the projection lens **41** and the aspherical mirror **50**. In contrast, in the ninth embodiment, a projection optics **300** does not include a projection lens **41** and is configured of a plurality of mirror groups.

(Configuration of a Projection-Type Image Display System)

A configuration of a projection-type image display system according to the ninth embodiment will be described below by referring to the drawings. FIG. **16** is a view (seen from a side) showing a configuration of a projection-type image display system **100** according to the ninth embodiment. Note that in FIG. **16**, similar reference numerals are given to denote components similar to those of FIG. **14**.

As shown in FIG. **16**, in the projection-type image display system **100**, a plurality of mirror groups (mirrors **151** to **155**) is provided in place of a projection lens **41** and an aspherical mirror **50**. Note that the mirrors **151** to **155** configure a projection optics **300**.

In the ninth embodiment, the mirrors **151**, **152**, **154**, and **155** are concave lenses and the mirror **153** is a convex lens, but of course, the combination of the mirrors is not limited to this.

In the ninth embodiment, an opening **362** is provided in the vicinity of the light-condensing surface *a*, but the configuration is not limited to this. Specifically, like the sixth embodiment, a protective cover **262** formed of a light-transmitting member may be provided in the vicinity of the light-condensing surface *a*. Or, like the eighth embodiment, a concave lens **263** condensing image light reflected by the mirror **155** provided in the last stage of the projection optics **300** may be provided in the vicinity of the light-condensing surface *a*.

## Other Embodiments

The present invention has been described by the above-mentioned embodiments, but the description and drawings which constitute a part of this disclosure should not be understood as to limit the scope of the present invention. For those

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who are skilled in the art, various alternative embodiments, examples, and operating techniques will be apparent from this disclosure.

For example, in the above-mentioned first embodiment, the entire protective cover is formed of a light-transmitting member, but the configuration is not limited to this. Specifically, it is only needed that a protective cover has a transmissive region transmitting image light condensed by an aspherical mirror **50** and only the transmissive region is formed of a light-transmitting member. Since the aspherical mirror **50** condenses the image light, the size of the transmissive region can be minimized, so that the light-transmitting member forming the transmissive region can be easily maintained.

In the second and third embodiments, shapes of the openings **161** provided in the protective covers **160** are an elliptical shape and a rectangular shape which is long in horizontal directions of the projection-type image display system **100**, but are not limited to those. Specifically, the shape of the opening **161** provided in the protective cover **160** is determined depending on the shape of condensed image light (a region *b*) condensed by the aspherical mirror **50** on the light-condensing surface *a*.

In the second to eighth embodiments, an aspherical mirror is used as a mirror reflecting image light outputted from a projection lens **41** to the screen **11** side, but the mirror is not limited to this. Specifically, a free-form surface mirror may be used as a mirror reflecting the image light outputted from the projection lens **41** to the screen **11** side. If an aberration and a resolution can be adjusted, a spherical mirror may be used as a mirror reflecting the image light outputted from the projection lens **41** to the screen **11** side.

According to each of the above mentioned embodiments, a reflection mirror is provided so that a distance between a projection-type image display device and a screen can be shortened. Thus, it is less likely that image light is interrupted by a person or the like coming in between the projection-type image display device and the screen. In addition, in a case where an LD is used as a light source **410**, the possibility that a person is accidentally irradiated with the laser beam (image light) can be reduced.

In the above-described embodiments, the display system provided with the screen of reflective type is explained. However, a screen of transmitting type may be applicable.

What is claimed is:

**1.** A projection-type image display device of front projector type comprising:

an image light generator configured to generate image light;

a projection optics configured to project the image light onto a screen, the projection optics including a projection lens configured to project the image light which is output from an image light generator, and a reflection mirror configured to reflect and condense the image light toward the screen and located closest to the screen side on an optical path of the image light which is output from the image light generator,

wherein a protective cover is provided on an optical path of the image light reflected by the reflection mirror so as to cover at least the outer side of the projection lens and the reflection mirror,

wherein the protective cover covers the projection optics and has a limited transmissive region transmitting the image light reflected by the reflection mirror, and

wherein the transmissive region of the protective cover is disposed in a position where the image light is condensed by the reflection mirror so that the area of the transmissive region is minimized to be smaller than the

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light incident plane of the protective cover so that the shape in area is similar to the cross section of the condensed light beam.

2. The projection-type image display device according to claim 1, wherein

the protective cover has an opening communicating from the reflection mirror side to the screen side and the transmissive region is the opening.

3. The projection-type image display device according to claim 2, wherein the transmissive region is a point that corresponds with a focal point for light passing through the transmissive region and projected onto the screen.

4. The projection-type image display device according to claim 1, wherein

at least one portion of the protective cover is formed of a light-transmitting member and the transmissive region is formed of the light-transmitting member.

5. A projection-type image display system of front projector type comprising:

- a screen;
- an image light generator configured to generate image light;
- a projection optics configured to project the image light onto the screen, the projection optics including a projec-

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tion lens configured to project the image light which is output from an image light generator, and a reflection mirror configured to reflect the image light toward the screen and located closest to the screen side on an optical path of the image light which is output from the image light generator; and

a protective cover provided on an optical path of the image light reflected by the reflection mirror, wherein

the protective cover covers at least the outer side of the projection lens and the reflection mirror and has a limited transmissive region transmitting the image light reflected by the reflection mirror, and wherein

the transmissive region of the protective cover is disposed in a position where the image light is condensed by the reflection mirror so that the area of the transmissive region is minimized to be smaller than the light incident plane of the protective cover so that the shape in area is similar to the cross section of the condensed light beam.

6. The projection-type image display system of front projector type according to claim 5, wherein the transmissive region is a point that corresponds with a focal point for light passing through the transmissive region and projected onto the screen.

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